

Extended Abstract for “The Role of High Mountains in the Global Transport of POPs”:
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Western Airborne Contaminants Assessment Project (WACAP): Assessing Deposition and Impacts of Persistent Organic Pollutants and Metals in National Parks in the Western United States

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INTRODUCTION

Persistent organic pollutants (POPs) and other semi-volatile compounds are susceptible to transport through the atmosphere to distant locations (1). Airborne contaminants tend to undergo deposition and subsequent accumulation in relatively cold environments, such as those found in high mountains and at high-latitudes. Airborne contaminants are driven out of the atmosphere by “cold condensation,” which dictates that semi-volatile compounds prefer the sorbed-phase over the vapor-phase at cold temperatures (2). Airborne contaminants are also subject to deposition in snow, which is the dominant form of precipitation in cold environments, due to the particularly high efficiency of snow at scavenging both vapor-phase and particle-bound contaminants in the atmosphere (3).

A significant body of research exists regarding the deposition of airborne contaminants to high-latitude environments, especially to those in the Arctic (4). The most comprehensive project regarding deposition to high mountains that has been conducted focused on European mountains (5). While there is evidence that atmospheric deposition of contaminants is occurring in North American mountains, our knowledge about the role of North American mountains in the global transport of contaminants is very limited. Yet, recent research indicates that mountains located along the Pacific Coast of North America are intercepting contaminant-containing air masses originating in Eurasia (6). As industrialization in the Pacific Rim escalates, the need to understand the relative contributions of trans-Pacific, regional, and local sources of airborne contaminants to sensitive high-elevation ecosystems in the mountains of western North American increases.

WACAP OBJECTIVES

The United States (U.S.) National Park Service is federally mandated to safeguard the ecosystems under its jurisdiction. Since much of the national parkland in the western U.S. is located at high-elevations and latitudes, the U.S. National Park Service is

compelled to determine the risk posed by airborne contaminants to the ecosystems and food webs in its western parks. Once deposited, airborne contaminants may accumulate and concentrate in foodwebs where they can impact reproductive success, growth, behavior, disease, and survival of animals high in the food chain, including fish, birds, and mammals.

Thus, the “Western Airborne Contaminants Assessment Project” (WACAP) was initiated in 2002 by the U.S. National Park Service to determine if airborne contaminants from long-range, regional, and/or local sources are impacting remote ecosystems in western national parks (7). The project is designed to take place over a five-year timeline: the first year (2002) was used for design and method development, the next three years (2003-2005) are being used for field sampling and analysis, and the fifth year (2006) is designated for preparation of final databases and interpretive reports.

The specific objectives of WACAP are to:

- 1) Determine if airborne contaminants are present in western national parks
- 2) If present, determine where contaminants are accumulating (geographically and by elevation)
- 3) If present, determine which contaminants pose a potential ecological threat
- 4) Determine which ecosystem components are most useful for assessing contamination, and
- 5) Determine the sources for contaminants measured at the national park sites.

APPROACH

Eight National Parks in the western U.S. were selected as primary parks for WACAP sampling. These include Sequoia, Rocky Mountain, Olympic, Mt. Rainier, Glacier, Denali, Noatak, and Gates of the Arctic. Two relatively high, small lake catchments were selected in each of the primary parks (except in the cases of Noatak and Gates of the Arctic where one catchment was selected for each), for a total of 14 field sites. The sampling sites are located across a latitudinal gradient ranging from 36° N to 68° N, a longitudinal gradient ranging from 105° W to 160° W, and an elevational gradient ranging from 427 m to 3030 m.

Seven ecosystem components are being sampled to provide information about contaminant accumulation and impacts in aquatic and terrestrial ecosystems.

- Snow. Contaminant concentrations are measured in the annual snow pack as a measure of direct atmospheric loading. Snow accounts for 50 to 90 percent of the annual precipitation.
- Fish. Ecological impacts of airborne contaminants will be assessed from fish samples. Contaminant concentrations in fish tissues will be compared to pathological and physiological endpoints.
- Lake Water. The condition of WACAP lakes will be characterized by assessing the chemical and physical characteristics of water quality, including trophic state, chemical contamination, and acidification.

- Lake Sediment. Sediment cores will be used to reconstruct long-term temporal trends in lake water contamination by dating core slices and measuring contaminant concentrations.
- Lichen. Contaminant concentrations in lichen, which act as passive samplers for air, will be used to assess contamination in biota of the park.
- Willow Bark. Willow bark is ubiquitous throughout the selected parks and relatively easy to sample. The bark sampling protocol is designed to elucidate patterns of contamination along elevational gradients within each park and along latitudinal gradients among different parks.
- Moose. Contaminant concentrations will be measured in moose, a key component in the diet of native peoples in Alaska, in an effort to include the human subsistence component of the Alaskan foodweb.

Airborne contaminants to be measured in ecosystem components include both semi-volatile organic compounds and metals. The target analyte list includes 85 different organic compounds, which were selected as molecular markers to estimate combustion, agricultural, and industrial source contributions from Eurasia and North America. In addition, by determining the enantiomer ratios of chiral compounds, it may be possible to distinguish between “new” and “historic” emissions and to track microbial degradation. The target analyte list for metals includes mercury, zinc, lead, cadmium, nickel, and vanadium.

A variety of tools will be used in conjunction with contaminant measurements to investigate probable sources of pollutants. These include local meteorological data, isentropic back-trajectories, satellite data, and global models such as GEOS-CHEM.

2003 ACTIVITIES AND INITIAL RESULTS

At the time of this writing, the 2003 and 2004 snow sampling campaigns have been completed. Analysis of 2003 snow samples for contaminants is near completion. Field activities during August and September 2003 involved 8-12 persons and 900 kg of scientific and field equipment that was deployed to two lakes in Sequoia National Park and two lakes in Rocky Mountain National Park over the period of 22 days. Summer field activities included sampling of snow, lichen, lake water, sediment, and fish.

Initial results indicate that current-use and banned SOCs are present in snow, lake water, and lichen in Sequoia and Rocky Mountain National Parks. Contaminants were found in snow samples collected in both the relatively low-latitude (e.g. Sequoia and Rocky Mountain) and high-latitude parks (Alaska parks). A broader range of contaminants were detected in Sequoia than in Rocky Mountain. However, all contaminants found in Rocky Mountain also were found in Sequoia. Contaminants found in the lake water (sampled in Sequoia and Rocky Mountain in 2003) in were also found in the snow, indicating that the contaminants are moving through the ecosystem components. Lichens (sampled only at Sequoia in 2003), which receive all of their nutrients and moisture from the atmosphere, had the greatest number of contaminants among the three sample types for which data is currently available.

SIGNIFICANCE

WACAP will provide significant new information about the role of the North American high mountains on the global transport of airborne contaminants, including many POPs. Final products will include a comprehensive database containing contaminant concentrations and other measured values from all ecosystem components. This database will summarize results concerning evidence of exposure, historical and seasonal trends, and bioaccumulation of airborne contaminants in the ecosystems of the western national parks. Information from WACAP will assist the parks in selecting approaches and indicators to be used in the potential future long-term monitoring efforts aimed at maintaining an ability to detect changes in atmospheric loadings of toxic compounds.

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